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## IMPACT OF PESTICIDAL POLLUTION IN THE ENVIRONMENT<sup>1, 2</sup>

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*(With two text-figures)*

The ubiquitous presence of residues of persistent pesticides in abiotic and biotic components of the environment is a matter of serious public concern. A brief review of the impact of pesticidal pollution on the ecosystem is given. Data obtained from Indus Basin (India) revealed widespread contamination of milk and wheat flour with DDT and HCH residues. Human adipose tissues also showed invariably the presence of DDT and HCH, the level of beta-HCH as high as 30 ppm was found in a sample. Potato and soil samples were found to be contaminated with negligible levels of insecticide residues. The possible implications of these residues have been discussed. Research and legislative needs to control the pesticidal contamination with particular reference to India have been outlined. It is concluded that the situation on the pesticidal contamination in certain components of the environment in India is quite serious and demands immediate action.

### INTRODUCTION

During the past three decades, organic pesticides have become increasingly important in controlling pests of crops, animals and man. These chemicals have greatly increased agricultural yields and saved millions of lives from insect-borne diseases. Unfortunately, the use

of certain persistent pesticides has resulted in the pollution of the environment. The main reasons for environmental pollution and serious ecological problems with pesticides are : 1. pesticides are biological poisons ; 2. large quantities are applied to the ecosystem; 3. poor application technology is used which results in large amounts of pesticides being widely spread in non-target areas ; 4. little pesticide (probably less than 1 per cent) ever hits the target pests and 5. persistence in the environment for periods longer than required or intended.

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When a pesticide is introduced into the environment, it enters a dynamic ecosystem and immediately begins to be moved from one part of the system to another, degraded *in situ* or move out of the system to other systems. Figure 1 portrays the various pathways by which pesticides cycle through the environment. Pesticides could conceivably have a biological impact throughout all parts of the environment since there is a continuous movement of these chemicals between soil, living organisms, water and air.

#### PESTICIDES RESIDUES AND THEIR EFFECTS

*Soil* : Large proportion of pesticides applied reach the soil, which acts as a reservoir for these chemicals. Their persistence in soil is very variable and depends upon complex interacting factors such as the characteristics of a pesticide, soil type, environmental factors, etc. (Lichtenstein 1972, Edwards 1975). The chemical structure of a pesticide and its resultant intrinsic stability is the most basic single factor. Factors that are next in importance are the adsorption of pesticide on to clay or organic fraction, precipitation, temperature and microbial activity. Amongst the organochlorine insecticides, DDT and dieldrin persist longest in soil, followed by endrin, lindane, chlordane, heptachlor and aldrin in order of decreasing persistence.

Persistent pesticides in soil may create a variety of hazards. Their residues concentrate into the bodies of the invertebrates and arthropods that live in soil, and from these they can be transported into the bodies of the higher organisms (Edwards 1970, 1973). Starting with DDT at a level of 9.9 ppm in soil, it reached a level of 141 ppm in the earthworms and 444 ppm in the brains of adult robins (Hunt 1965). This high concentration in the robins was toxic to some birds. Soil invertebrates

also take up some of the organophosphorus and carbamate pesticides. Recently, Edwards (1976) found that slugs concentrate large amount of diazinon and phorate from soil and considered that this may constitute a serious danger to birds and mammals which feed on them, even if slugs were unaffected, because of the high toxicity of these insecticides to vertebrates.

Soil micro-organisms which cause or contribute to the breakdown of cellulose, nitrification, turn over of organic material and other biological materials may be adversely influenced by pesticides. For example, EPTC (herbicide) at normal dosage impaired cellulose decomposition in soil. Another herbicide (TCA) reduced soil nitrification (Pimentel and Goodman 1974). Earthworms and arthropods have been severely reduced by insecticides and herbicides. Simazine at a normal dosage caused a reduction in a number of soil invertebrates by 33 to 50 per cent (Edwards 1964). Predatory mites, hemeidaphic Collembola and particularly the Isotomidae were most affected by Simazine. DDT and some of the organophosphorus insecticides increased many species of spring tails and some species of non-predatory mites even to the extent of increasing the total biomass. The duration of ecological imbalance following the application of pesticides, however, was found to depend upon the persistence of chemical and its absolute toxicity. A general consensus is that most pesticides do not affect microbial population if applied at the recommended dosage but may cause serious ecological problems if their dosages are exceeded.

Fortunately residues of persistent organochlorine insecticides do not concentrate from soil into plant tissues but nevertheless the small quantities in plant tissues which are used for human food may be undesirable. A further hazard is the development of resistance in soil pests due to their continuous exposure to persistent pesticides present in the soil.

*Aquatic systems* : There are many routes by which pesticides can reach the aquatic environment such as rivers, lakes, oceans and ponds. These routes are (a) surface run-off and transport from treated soil ; (b) industrial wastes discharge and factory effluents ; (c) direct application as aerial sprays or granules to control water-inhabiting pests ; (d) spray drift from normal agricultural practices ; (e) atmospheric transports ; (f) municipal water discharged into sewage effluents ; (g) agricultural wastes and (h) accidental spillage (Kilgore and Li 1976, Edwards 1977). It is considered that run-off from agricultural land is the main source of gradual pollution, with direct application to water and discharge of effluent into aquatic systems causing more serious but localized contamination. The pesticides that cause maximum pollution are the organochlorine insecticides and certain persistent herbicides. Pesticide residues have been found to be the largest in rivers, less in estuaries and least in the ocean.

Pesticides in the aquatic environment constitute both direct and indirect hazards to man as well as to aquatic animals. Of particular concern, is the phenomenon of 'bioconcentration' of persistent organochlorine insecticides like DDT, dieldrin, DDD, etc. One of the first studies of build-up of organochlorine insecticides in an aquatic ecosystem was conducted in California in 1958 by Hunt and Bischoff (1960). DDD insecticide was applied several times to clear lake to control gnats. The level of insecticide in water immediately following the last application was calculated to be 0.02 ppm. Residue levels of DDD in samples taken from the lake 13 months after treatment were 10 ppm in plankton, 903 ppm in fat of plankton-eating fish, 2690 ppm in fat of carnivorous fish, and 2134 ppm in fat of fish-eating birds. These residues represent about a 500-fold increase in levels in plankton and a 100,000-fold increase in fish-eating birds over levels occurring in

lake water after treatment. The high levels of pesticide residues, thus, acquired by the birds caused mortality in Western grebes. This process of 'bioconcentration' is sometimes confused with that of 'biological magnification' which can be defined as the accumulation of a pesticide in an animal in any particular trophic level of a concentration greater than that in its food or the preceding trophic level so that eventually, animals at the top of food chain accumulate the largest residues. The food chain concept is particularly questionable in aquatic system, because, although there is a marked tendency for the organisms in the higher trophic levels to accumulate larger amounts of persistent organic pesticides, there is a good evidence that these organisms can obtain these residues as readily from the water in which they live as from their food (Moriarty 1973).

Many fish kills attributable to pesticides have been reported. Such events frequently result from accidents and ignorance. Dramatic fish kill becomes immediately obvious, there is considerable public outcry and the causes are usually eliminated or controlled. Gradual contamination, however, carries greater potential environmental hazards. Observations on sublethal effects of pesticides are accumulating and there are indications that indirect effects on the ecosystem, such as the disturbance of population dynamics, changed food requirements, reproductive behaviour and photosynthesis may be quite important.

*Air and Atmosphere* : Pesticides enter the atmosphere by a variety of routes, particularly from spray drift or volatilization from soil or water. Other routes of entry include wind erosion and agricultural burning. The use of aircraft for pesticidal application undoubtedly contributes greatly to the air contamination. Many studies have revealed the presence of residues of pesticides in air and rain samples. Risebrough *et al.* (1968) suggested that insecticides can be transported long distances by



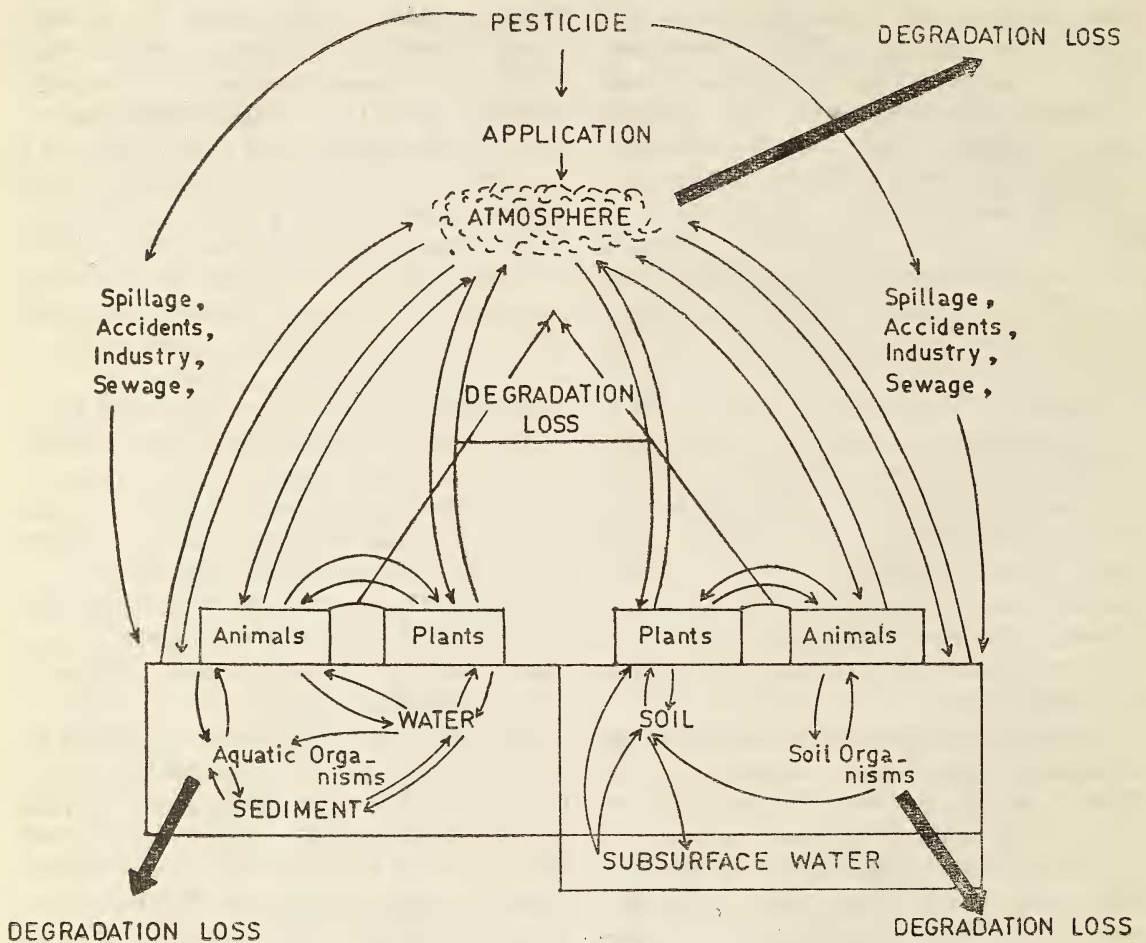


Fig. 1. Pesticide cycle in the environment.

global air currents in the same way as occurs with radio isotopes such as Strontium-90 and Cesium-177 and then fall out on to land or water in pattern dependent upon local precipitation. The significance of this route for the unexpected contamination of untreated soil and water situated far off from the places of application is still to be ascertained. Current evidence indicates that hazards from pollution of the atmosphere by pesticides are still small, particularly when compared with those from pol-

lution of air by other materials. The amounts of pesticides in air are unlikely to be harmful to general public breathing air because the concentrations found have been quite small. *Agricultural crops and other food commodities* : Pesticides residues in food are often a matter of major concern to the public. Nevertheless, it is very difficult to produce crops that contain no insecticide residues without serious losses due to pests. Domestic animals are also continuously exposed when they eat insecticide



contaminated feed. This results in the contamination of milk and meat. It is important that food commodities for man should not contain pesticides residues at levels hazardous to human health. In many countries, pesticide residue tolerances have been fixed for the maximum amounts of residues that may occur in plant tissues or other food commodities after taking into considerations the legitimate need of agriculture and the acceptable daily intake (ADI).<sup>4</sup> As a result of these requirements, there have been extensive studies of insecticide residues in food commodities in many countries of the world. It is reassuring to find that in most countries, the daily intake of these pesticides through well-balanced diets have been only a small fraction of the 'ADI' (Corneliussen 1970, Duggan and Corneliussen 1972, Abbot *et al.* 1969, Carassco *et al.* 1976).

*Birds and wild life* : The residues of organochlorine insecticides have been reported to occur in the tissues and eggs of many species of birds. The concentrations varied greatly and the quantities found were associated with the habits and food of the birds. Generally, there were much more insecticides residues in raptorial and fish-eating birds than in herbivorous birds ; particularly large amounts have been found in Herons and Great-crested Grebes and their eggs. The population of several of the bird species is declining such as the bald eagle, Osprey, peregrine falcon and brown pelicans, whereas it is increasing in other species such as the black bird or starling, quail, pheasant and robin. Pesticides probably are a contributing factor to this decline. Research has produced evidence that pesticides have and are affecting the reproduction in some species, both in egg laying and in the thickness of the egg shell (Wiemeyer and Porter 1970,

Bitman *et al.* 1970). However, not all members of the particular family show the same reproductive failure. The egg shell effects are generally attributed to the pesticide causing a change in calcium metabolism. It is very difficult to assess the hazards of pesticidal pollution on birds and other wild life as only a small proportion of the total species have been investigated.

*Man* : The intake of pesticides through food and other sources result in their accumulation in the body tissues of human beings. The most common insecticide found in the general population was DDT. Aldrin, dieldrin, BHC, heptachlor and its epoxide etc. were the other insecticides detected. Residents of different countries have been found to contain different mean levels of DDT, for example, Germany 2.3, Netherlands 2.0, Denmark 3.1, Great Britain 3.0, Czechoslovakia 9.2, Italy 10.1, Hungary 12.4, Poland 13.4, Israel 18.1 and India 28 ppm (Matsumura 1975). The high levels of DDT residues in the general population in India was further confirmed by Ramachandran *et al.* (1974) and Vir (1977). It has been shown that these chemicals can be transferred from the mother to the foetus so that babies may be born with insecticides in their tissues. Another susceptible reproduction-related system is the mother-child transfer of pesticides via milk. The most likely effects of low-level residues of persistent organochlorine insecticides in man are the 'induction effects' on the hepatic microsome enzyme systems. The significance of this phenomenon on human health is not fully understood as yet. Data presently available do not suggest that man is being harmed by the small quantities of the pesticides present in his tissues. The long-term and delayed effects of these pesticides are, however, quite difficult to assess.

The consumption of methyl mercury derived from sea food resulted in the outbreak of

<sup>4</sup> The daily dose of a chemical which appears to be without appreciable risk to man on the basis of all facts known at that time.

Minamata disease in Japan. This occurrence was of course localised in areas of mercuric pesticide usage but do emphasize the possibility of development of serious situation if timely proper precautions are not taken in the use of pesticides.

*Ecosystem effects* : Pesticides impinge at all levels of organisation—at levels of the cell and the organs and at levels of the individual, the population and the ecosystem. Since each species in a community is affected differently by an introduced toxicant, the entire community organisation changes often resulting in outbreaks and the general instability of the ecosystem (Moore 1967 ; Pimentel 1971; Pimentel and Goodman 1974). For example, when predaceous coccinellid beetles and other predator and parasite populations were unintentionally eliminated in areas treated with DDT, chlordane and other chemicals, outbreak of mites (Helle 1965), aphids (Pimentel 1961) and scale insects (De Bach 1947) occurred. The densities of these plant pests increased 20-fold above the control levels usually achieved through their natural enemies. There has been an increase of green leaf hoppers on rice in areas of intensive use of BHC and of white flies on cotton after the introduction of DDT in the Sudan Gezira. According to FAO/WHO (1975), such pesticides induced disturbances may be more severe in tropical countries where ecological conditions tend to favour control by natural enemies. The use of pesticides has also been reported to alter the natural habitat (Pimentel and Goodman 1974). Plants, humans and other animals are all parts of the same system or 'establishment'. If the life system is altered, it may have serious repercussions on the nature and functions of the ecosystem and ultimately on man.

One of the more serious long-term effects on populations has been the evolution of resistant strains of pests to pesticides (Perry 1974). The

effect of this pesticide resistance on the ecosystem is varied. Species with large amounts of genetic variability can evolve a high degree of tolerance and become the dominant species in the pesticide-stressed ecosystem. The possibility of the alteration in the dynamic equilibrium of the whole biotic community cannot be overlooked through such changes in the dominance by some species. In addition to pests, pesticide-tolerant or resistant populations of fish have been shown to exist in areas subjected to sustained pesticide usage. No top carnivores were found in nearly 100 hours' collecting in this area, suggesting that the resistance may involve increased ability to store toxic residues to the detriment of animals higher in food chain (Ferguson *et al.* 1964).

#### PESTICIDES CONTAMINATION LEVELS IN THE INDUS-BASIN (INDIA)

The information on the nature and levels of pesticidal contamination in various components of the environment in the Indus-Basin (India) is available only from the Punjab State and that too is as yet fragmentary.

According to the estimates made by the Ministry of Agriculture, Govt. of India, the consumption of pesticides in the Punjab is about 3600 metric tonnes per year (Anon. 1976). Most of these are insecticides, the important being HCH, carbaryl, malathion, DDT, fenitrothion and endosulfan. The total use of these six insecticides is about 2350 metric tonnes. However, these figures do not seem to have taken into account the use of insecticides for the control of malaria. DDT and HCH are the two main insecticides being used for malaria control. About 700 metric tonnes of DDT per year are being sprayed for this purpose in the Punjab. Cotton, vegetable, oilseed etc. are the major crops being sprayed with these insecticides. However, it is apparent from the

data given below that the present use of insecticides is still not very extensive on most crops except for vegetables (Sidhu, A. S.,—personal communication).

Crop	Total area (ooo ha)	Per cent area covered
Cotton ..	240	25
Rape and mustard ..	180	25
Maize ..	560	10
Sugarcane ..	100	10
Potato ..	22	50
Other vegetables ..	38	75

Soil, human adipose tissues and a few food commodities have so far been analysed for insecticides residues (Table 1). Residues of both DDT and HCH were detected in most of the 250 samples of wheat flour collected from different cities in the Punjab (Joia *et al.* 1978). About 20 per cent of the samples contained DDT residues at a level above 1 ppm while a single sample contained even more than 5 ppm DDT. HCH residues exceeding 1 and 5 ppm were found in about 30 and 4 per cent samples respectively. Indications were obtained that the contamination of wheat with DDT at low levels could also occur through sources other than their direct admixture. Earlier Bindra *et al.* (1973) reported the results of analysis of 54 samples of wheat collected from the farmers' households and grain markets. Of the 40 per cent samples contaminated, 17 contained DDT alone while 4 contained HCH.

The overall mean level of DDT and HCH residues in wheat flour in the Punjab was found to be about 0.4 and 1 ppm respectively. As most of DDT and HCH residues were retained intact even during *chapati* preparation (Chawla *et al.* 1979), the daily intake of DDT and HCH by an adult comes to about 208 and 519  $\mu\text{g}$  respectively (Table 2). Thus, the daily intake of DDT through cereal alone is about 69 per

cent of the prescribed safe level (ADI) of 0.005 mg/kg/day (FAO/WHO, 1975) and is much higher than the total dietary intake of DDT in USA (55  $\mu\text{g}$ ), England (34  $\mu\text{g}$ ) and Spain (70.4  $\mu\text{g}$ ), (Carasco *et al.* 1976). Similarly, the calculated daily intake of HCH (519  $\mu\text{g}$ ) through wheat flour in the state was found to be much higher than that in the U.K. (17  $\mu\text{g}$ ) (Brooks 1972).

The contamination of milk with DDT was fairly widespread in the Punjab (Dhaliwal and Kalra 1977, Kalra *et al.* 1978). The residue level of DDT in most of the samples collected from the rural areas and the depots of Punjab Dairy Development Corporation, situated in Ludhiana, Chandigarh, Bhatinda and Amritsar was more than the maximum permitted level. Some samples even showed as high as 10-17 times the permitted level of DDT residues. HCH-residues mostly in the form of alpha-and beta-isomers were also detected. Butter and baby milk food also showed the presence of DDT and HCH residues (Dhaliwal and Kalra 1978, Kalra *et al.* 1979). The contamination of milk is to be viewed with concern as it is consumed in substantial quantities by infants and the sick. The contaminated milk, if taken by a 3 month child weighing 5 kg at the rate of 875 ml (5 feeds of 175 ml each) per day could result in a daily intake of 225  $\mu\text{g}$  of DDT (Table 2). This is 9 times higher than the 'ADI' of 0.005 mg/kg/day. The consumption of baby milk food is also likely to result in the intake of DDT at levels higher than the levels accepted to be safe. As children are considered to be more susceptible than adults, they are at a much greater risk. The major portion of DDT residues was found in the form of p, p'-TDE. The high level of TDE in milk suggests that the intake of DDT in cattle probably occurs through the contaminated cattle feed (Witt *et al.* 1966). As limited amount of DDT is being used in agriculture, the contamination of cattle feed with excessive DDT



TABLE 1

## PESTICIDE RESIDUES IN THE PUNJAB ENVIRONMENT

Matrix		Period of sampling	Samples examined	Samples found contaminated	Insecticide detected	Range (ppm)
Wheat grain	..	1970	54	17 4	DDT HCH	4 to > 6 > 4
Wheat flour	..	1974-76	250*	210	DDT	Tr. - 10
		1976	140	112	HCH	Tr. - 12
Bread	..	1977	9	9 9	DDT HCH	Tr. - 0.15 Tr. - 0.1
Pulse	..	1976	10	6 5	DDT HCH	Tr. - 1.02 Tr. - 0.05
Milk	..	1976	102	102	DDT	Tr. - 1.02
			42	25	HCH	Tr. - 0.05
Butter	..	1977	6	6	DDT	3.11-5.86
		1978	15	15 15	DDT HCH	2.61-8.19 0.51-5.35
Infant food	..	1977	1	1	DDT	2.72 (fat basis)
Poultry egg		1976	20	20 14	DDT HCH	0.05-0.97 0.07-0.62
Potato	..	1974	20	20	DDT, aldrin, HCH, heptachlor and dieldrin	Tr.-0.05
Okra	..	1967-68	6	6	Endrin	0.06-0.38
Brinjal	..	1964	10	4	DDT	0.08-8.0
Tomato	..	1964	10	1	DDT	0.08
Animal Feed Straw	..	1975-78	35	29 24	DDT HCH	Tr. -0.75 Tr. -0.6
Fodder		„	13	10 8	DDT HCH	0.02-0.5 0.1-0.2
Concentrate	..	„	12	12 12	DDT HCH	0.07-0.89 Tr. -2.0
Human Adipose Tissues	..	1976-78	51	51 50 4	DDT HCH Dieldrin	0.7-31.34 Tr. -30.05 Tr. -1.20
Soil	..	1976-77	106	89 1 1	DDT HCH Endrin	0.07 (1.63)** 0.5 0.1
Water	..	1976	2	2	DDT	Tr.

\* These include the 140 samples examined for HCH also.

\*\* Arithmetic mean (Maximum value).

Tr. indicates traces.

# PESTICIDAL POLLUTION

TABLE 2

ESTIMATES OF DIETARY INTAKE OF DDT AND HCH THROUGH CONTAMINATED FOOD COMMODITIES IN THE PUNJAB

Adult/ Infant and weight (kg)	Food commodity	Estimated mean consumption* (g or ml/day)		Insecticide and mean level of contamination (ppm)	Calculated daily intake ( $\mu$ g)		Proportion of the acceptable daily intake (%)	
		Actual diet	Balanced diet		Actual diet	Balanced diet	Actual diet	Balanced diet
Adult, 60	Cereals	519	370	DDT, 0.4	208	148	69	49
-do-	-do-	-do-	-do-	HCH, 1.0	519	317	**	**
-do-	Milk	317	180	DDT, 0.26	82	47	27	16
Infant, 5	-do-	875	—	DDT, 0.26	225	—	900	—
-do-	Baby milk food	135	—	DDT, 0.35	47	—	190	—

\* The estimated mean consumption of food items for the adult is from 'Diet Atlas of India' by Gopalan, C., Bala Subramanian, S. C., Ramsastri, B. V. and Visweswara Rao, K. (1971), Indian Council of Medical Research.

\*\* The ADI for HCH has not been established so far. The ADI for gamma isomer is 0.0125 mg/kg/day.

residues is rather unexpected. Butter samples obtained from Haryana and Rajasthan also showed excessive DDT and HCH residues indicating concentration of the residues from contaminated milk (Dhaliwal and Kalra 1978 ; Kalra *et al.*, 1979).

DDT and HCH residues were also present in the samples of poultry eggs collected from Ludhiana but their levels rarely exceeded the maximum permitted residue limits. Market samples of potatoes collected from the different cities in the Punjab showed invariably the presence of DDT, HCH, aldrin, heptachlor and dieldrin. However, their levels in most of the samples were negligible (Kalra *et al.* 1978). DDT residues were detected in the market samples of brinjal (Jaglan and Chopra 1970) while endrin was detected in the samples of okra (Bhalla *et al.* 1970).

Biopsy samples (51) of the adipose tissues of human being collected from the Daya Nand Medical College, Ludhiana, when analysed

invariably showed the presence of DDT and HCH. The residues of HCH in few samples were found to be quite excessive. As high as 30 ppm of beta-HCH, which is known to accumulate in human body, was found in a female fat sample (Chawla *et al.* 1978).

Recently, the soils of Punjab and Chandigarh were surveyed for insecticide residues (Singh 1977). A total of 106 surface soil samples were collected at random from all over the constituent districts of the Punjab and Union Territory, Chandigarh. More than 80 per cent of the samples were contaminated with DDT. The mean level of total DDT-R was found to be 0.03 ppm whereas the maximum level found was 1.73 ppm. These values were much lower than those found in countries like USA and Canada. This could be attributed to the relatively faster rate of loss of DDT under subtropical conditions as observed by Agnihotri and Jain (1977) in Delhi and Talekar *et al.* (1977) in Taiwan. Interestingly, Vir (1977)

found a much higher level of DDT (4.2 ppm) in surface soil in areas located around the DDT factory in Delhi.

The presence of DDT and BHC residues in wheat, milk and eggs is a matter of concern particularly in view of the fact that practically no usage of these insecticides is directly related to the production of these commodities. However it is reassuring to find that potatoes for which aldrin and heptachlor have been recommended, contained only negligible amount of organochlorine insecticides.

#### RESEARCH AND LEGISLATIVE NEEDS

Although considerable amount of work is being done on the development of non-chemical methods of pest control, yet the general consensus is that these methods have not reached a stage that they can supplant the use of chemicals in the foreseeable future. Our needs to use pesticides will, therefore, continue to increase. Nevertheless, we cannot ignore the potential risks. In the use of pesticides, we must, therefore, be keenly aware of, and concerned, and knowledgeable about their effects on man's total environment. The prime objectives of research and regulatory programmes are the achievement of pest control without injury to man, animals, plants, soil, fish, or wild life and other values in man's total environment. Determining the effect of pesticides on environmental quality is extremely complex problem and our understanding is far from complete. Winteringham *et al.* (1974) suggested 'integrated and comparative approach' to the problem of environmental contamination at scientific level. This approach is system-analysis type and there are significant information flows in both directions between any two kinds (Fig. 2). It is considered that this approach would provide rational basis for the development of necessary counter measures, regulatory

action control and would also help to identify priorities.

In order to gain a better perspective about the potential for pesticide contamination in the environment, the amount of pesticides used now and in the past must be known (Box II). The environmental impact may depend not only on a country's total consumption but also on the kinds and rates of application on crops. Although some figures on the total consumption of pesticides in India are available, the data on the pattern of their usage are scanty. Realizing the importance of such data, USA and many countries in the European Common Market have initiated extensive programmes for its collection. It hardly needs any emphasis that such an information will help in the identification of problems resulting through the actual use of pesticides.

Wide-scale and intensive monitoring investigations to estimate the levels of pesticides in the biotic and abiotic component of environment are being carried out in the western countries, with the aim to detect any undesirable concentration of a pollutant as and when it arises so that an appropriate action may be taken before any detrimental effect occurs (Box III). In India, no national monitoring programme for pesticides residues has so far been initiated. Limited and scattered surveys have only been done to find out the extent of pesticidal contamination in food material (Bindra and Kalra 1973, Lakshminarayana and Krishna Menon 1975, Agnihotri *et al.* 1974a & b), soil (Singh 1977, Vir 1977) and human adipose tissues (Ramachandran *et al.* 1974). Monitoring is defined as 'the process of repetitive observing, for defined purpose, of one or more elements or indicators of the environment according to pre-arranged schedules in space and time, and using comparable methodologies for environmental sensing and data collection'. Thus, monitoring is normally of long-term nature and differs from a survey, which is



# PESTICIDAL POLLUTION

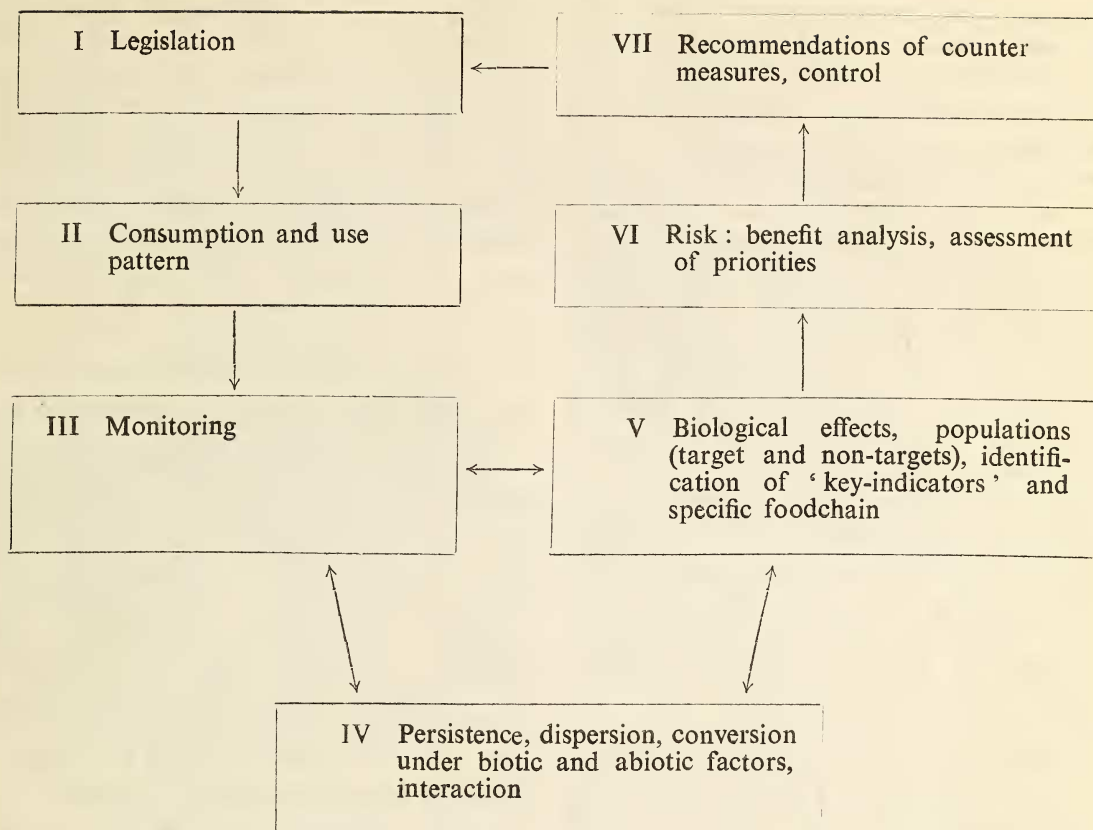


Fig. 2. Integrated and comparative approach to pesticide residues in biosphere (Winteringham *et al.* 1974 with modification).

usually short-term and often comprises only one period of sampling at each sampling site (Holden 1975). Obviously, there is an immediate need for initiation of monitoring programme for pesticides residues in India.

Sufficient information on the fate of pesticides from relevant uses must be acquired (Box IV). Microbial action, volatilization, adsorption, leaching, chemical/biochemical reactions, photodecomposition and absorption by plants, etc. are the key processes that influence the behaviour of pesticides in soil, water, plants and other living organisms as also their movement in the ecosystem. Although considerable

progress has been made in understanding these phenomena in temperate region, there is a little information available in sub-tropical countries like ours (Bindra and Kalra 1973, Kalra 1977, Agnihotrudu and Mithyantha 1978). These studies are essential for the judicious use of pesticides and might help in the identification of the sources of the known occurrence of environmental contamination.

Some species populations in the life system, either because of their known susceptibility to pesticides or as they are particularly vulnerable due to their position in the particular ecosystem, may serve valuable role of 'key indicators'.

They will 'tell us' when pollutant level may be reaching dangerous level in the environment. 'Key indicator species' that readily take up and concentrate residues may be identified in the aquatic and terrestrial ecosystem. It is also important to study the transfer of pesticides through specific food chains and their magnification in humans, animals and wild life. Such studies will enable early detection of the problem situations so that remedial action may be taken (Box V). Practically no work has been done on this aspect in India excepting that of Vir (1977) who found that the local species of earthworm, *Pheretima posthuma*, concentrate DDT residues from soil.

It is becoming increasingly apparent that the benefits of using pesticides must be considered in the context of present and potential risks of pesticide usage (Box VI). Both risks and benefits could vary significantly from country to country, or even from one period of time to another in the same geographical area. For example, persistent organochlorine insecticides like DDT and HCH which have been restricted from use in the western countries are still used in large quantities (about 85 per cent of the total pesticides consumption) in India. However, sound and objective judgements can only be made by the decision-making bodies if systematic information is available both on the benefits and risks. One could appreciate that it will not be possible to have any assessment of risks in the absence of data on the fate and significance of foreign chemical residues, the susceptibility of the exposed plant or animal species (both target and non-target species) or which significant food chain is involved under the particular local conditions. There is serious doubt that the correct assessment of the benefits through pest control programmes is even being made in India. The cases of malaria are showing a steady increase in spite of extensive use of DDT for its control. It may be noted that the malaria vectors have

become resistant to DDT almost all over the country. The present-day emphasis is that the use of any pesticide in pest control programmes must be assessed on the basis of three important criteria, economics, public health, and environmental pollution. All three are important and a serious deficiency in any one of these would prevent the pesticide from being used. Unfortunately, no attempt is being made in India to assess even the important pest control programmes such as the use of pesticides for public health purposes and for the protection of crops like cotton, rice, etc. on the basis of these criteria.

Although most of the dangers from unregulated and indiscriminate use of pesticides were known quite early, it was only in 1968 that the comprehensive 'Insecticides Act, 1968' was passed. The Act provides to regulate the import, manufacture, sale, transport, distribution and use of pesticides with a view to prevent risks to human beings or animals and for other matters connected therewith. In addition, we have Prevention of Food Adulteration Act, 1954 under which the provision exists for prescribing the pesticides residues tolerances in food commodities. The registration of pesticide is done under the Insecticides Act, 1968. The burden of proving that a pesticide is safe within the requirement of a scheme lies with the manufacturers. However, most of the manufacturers of pesticides in the country do not have facilities for generating the required data for the purpose of registration. Although the Prevention of Food Adulteration Act is on the statute for about the last 25 years, it does not seem to have been implemented at all to regulate the pesticides residue in the nation's food supply. If such a law is to be effective, it would require very effective machinery which may not be provided for many more years to come. However, it must be realised that most of the problems in controlling pesticides arise from the lack of

appreciation that they are product of a technological society. The law may prescribe, proscribe, or regulate anything so long as those requiring the control can explain exactly what they want and the criteria which they wish to apply in order to achieve the end. The important input for the success of pesticides legislation is, therefore, knowledge in the form of scientific data (Box I).

### CONCLUSIONS

Pesticides are indispensable and invaluable inputs for increased agricultural production. However, this considered indispensability does not justify their use in an irresponsible manner. As is apparent from the foregoing account, the intelligent utilization of pesticides would depend on the fundamental knowledge of the behaviour and effects of pesticides in the ecosystem. Clearly, the pesticidal contamination of the environment in India needs immediate attention in view of the following evidence :

- First. The high levels of DDT residues in the adipose tissues of the Indian population.
- Second. The widespread contamination of milk with excessive DDT residues.
- Third. The estimated dietary intake of DDT in India exceeds the ADI.

The pollution with pesticides is not easy to perceive. Changes in the ecosystem take place so slowly that the problem may become visible only after it has taken a serious turn making it difficult to reverse the trend of negative effects. Therefore, any further complacency may have serious consequences.

Substantial monetary gains in the form of increased agricultural production are obtained through the use of pesticides. In India, pesti-

cides worth 100 crores of rupees are being used every year. The conservative net gain through their consumption may be put at 400-500 crores of rupees. Appropriations of at least 2 per cent of this net gain should be diverted to research so as to develop strategies in the rationale of pesticide use.

Each and every law has an element of assurance for the general public. Pesticides legislations are supposed to provide assurance to the people against the possible harmful effects of pesticides on man and his environment. However, both the Insecticides Act and the Prevention of Food Adulteration Act (PFA rules) have remained practically unimplemented with respect to the contamination of the environment. The literature being issued by the firms, mainly based on the data collected in western countries, contains recommendations on the use of pesticides which are likely to leave residues more than the prescribed maximum limit under certain situations. One wonders on whom the onus for the presence of residues above tolerances under the PFA rules will lie when the sources of contamination of food commodities like wheat, milk, etc. remain obscure. We should not feel shy to accept the realities of the situation. It is suggested that an 'Expert Working Group on Pesticides Residues' may be constituted to take stock of the present situation, decide priorities, suggest an action plan for immediate implementation through the co-operative efforts of the Government, Industry and related organisations, and help the Government in rationalization of its policy.

It is well recognized that many of the hazards result through the improper usage of the pesticides. If we are to maintain a satisfactory cost/benefit/risk ratio, we must select pesticides carefully and use them correctly and safely. Education on the safe and proper usage of pesticides can go a long way to achieve this.



In the end, it is not inappropriate to state that the use of pesticides is not an ecological sin. Rather, the pesticides are capable of improving the quality of life and environment provided their use is based on sound scientific principles.

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